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(54) CENTRIFUGAL LIQUID PUMP WITH INTERNAL GAS INJECTION ASSEMBLY

ZENTRIFUGALE FLÜSSIGKEITSPUMPE MIT INWENDIGER GASINJEKTIONSVORRICHTUNG

POMPE CENTRIFUGE A LIQUIDES, MUNI D'UN ENSEMBLE INTERNE D'INJECTION DE GAZ

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Description

BACKGROUND OF THE INVENTION

a) field of the invention

[0001] The present invention relates to a method for injecting and dissolving a gas, such as air, into a liquid that is preferably water, while this liquid is being pumped by a centrifugal pump of the rotary disc type.

[0002] The invention also relates to a centrifugal liquid pump of the rotary disc type, incorporating a gas injection assembly.

b) brief description of the prior art

[0003] In the flotation processes that are presently used for "clarifying" or otherwise treating waste water it is of common practice to recycle part of the clarified water. Usually, the clarified water is pumped at the bottom of the flotation tank of the clarifier or at the outlet of the same and injected into the waste water to be treated just before it enters the clarifier.

[0004] It is also of common practise to inject air into the waste water that enters the clarifier, in such a manner as to generate a multitude of very small bubbles which "catch" the solids in suspension in the waste water and thus favorize flotation of the same. Such an injection can be made either directly into the waste water fed to the clarifier, just before it enters the same, or preferably into the clarified water that is recycled prior to its injection into the waste water. In both cases, the injection is preferably made under pressure so as to dissolve as much air as possible in the water.

[0005] In order to recycle a sufficient amount of clarified water and simultaneously allow dissolution therein of a sufficient amount of air to generate a multitude of micro bubbles of 150 micromillimeters or less as soon as the pressure is released, the pump must ideally generate a pressure of 550 to 825 kN/m^2 (80 to 120 lbs). Of course, it must also have ideally a low energy consumption (expressed in m^3 per horse power).

[0006] To meet these goals, use has been made so far of centrifugal multistage pumps with bladed impellers that can build up pressure up to 1380 kN/m^2 (200 lbs). However, these pumps have a low flow rate.

[0007] It has also been suggested to use rotary disc pumps comprising a plurality of closely spaced apart discs rotatably mounted within a casing (see for example U.S. patent Nos. 4,335,994; 4,514,139; 4,768,920 and 4,773,819). In this particular case, the pumping effect is obtained by frictional and shear forces developed between the rotating discs and the fluid. To improve such an effect, it has also been suggested to provide radial straight ribs on each disc (see U.S. patent No. 4,940,385).

[0008] Rotary disc pumps are interesting in that, thanks to their structure, they can easily handle a fluid such as waste water, which may contain solids in suspension. However, they are really effective only when the pressure to be built up is lower than 350 kN/m^2. Moreover, they are known to be energy consuming (maximum of 1 m^3/HP).

[0009] To provide the required dissolution of air in the recycled water (or in the waste water fed into the clarifier), it is of common practice to provide an air inlet in a venturi located upstream the pump, so as to suck air with and into the water and to compress with the same within the pump (see, for example, Canadian patent No. 1,016,408, even if it is directed to another application).

[0010] In this very specific field, it has also been suggested to inject air directly within the casing of the pump, either through conducts made in the blades of the impeller and opening at the outer ends of these blades (see U.S. patent No. 3,485,484) or through stationary pins extending in the casing of the pump, the blades of the rotor then being split at a given radial distance from their rotation axis not to interfere with the pins (see U.S. patent No. 4,744,722). In both of these cases, the casing and/or the impeller or rotor is/are of very specific structure, thereby making the pump rather expensive and its structural components sometimes difficult to repair and/or easily interchange.

[0011] It is known that with bladed impeller multistage pumps capable of building up high pressure, it is possible to mix up to 20% per volume of air in the water flow. With the conventional rotary disc pumps which have no ribs on their discs and cannot build up a high pressure, one may mix up to 7% per volume of air only, and only if the discs are close to each other and rotate at a speed of 1700 to 2100 rpm. However, in practice, from 10 to 15% per volume of air are required to make the waste water treatment efficient in the clarifier.

[0012] In French laid-pen patent application No. 2,253,716, a liquid manure aerating assembly is disclosed, which comprises an axial air sucking pipe and a set of radially projecting air feed pipes rigidly connected to a circulating impeller consisting of a single disc from which a plurality of blades project. The purpose of this assembly is to mix air with liquid manure and to circulate of the resulting mixture through a manure tank that has previously been fed with manure by an external pump. In operation, the only pressure that must be *"built-up"* by the impeller is the pressure loss occurring during circulation of the manure within the tank. Such a pressure is very low. As a result, the impeller can be positioned close to the top surface of the liquid manure, so as to suck in not only the liquid manure but also the foam floating on top of it.

[0013] Any "real" centrifugal pump which must generate a pressure of at least 500 kN/m^2, would not be able to work this way and would unprime under the same operating conditions, especially if, as is shown in this French application, the impeller driving shaft passes through the casing inlet and thus substantially reduces the surface area of the same.

OBJECTS AND SUMMARY OF THE INVENTION

[0014] The object of the invention is to provide a centrifugal liquid pump of the rotary disc type, which incorporates a gas injection assembly of very simple yet efficient structure, whereby a liquid can be pumped at a pressure of more than 550 kN/m^2 with a flow rate as high as 190 m^3/h while, at the same time, up to 15% per volume of a gas such as air is injected and dissolved at least in part into the pumped liquid.

[0015] More particularly, the centrifugal pump according to the invention is intended to be used for pumping a liquid while simultaneously injecting a gas into the liquid that is being pumped.

[0016] Like the liquid manure aerating assembly disclosed in French laid-open patent application No. 2,253,716, this pump comprises:

a) a casing defining an inner, substantially cylindrical chamber, said chamber having a pair of opposite end walls coaxial with each other;
b) a liquid inlet in open communication with the chamber, this inlet being coaxial with said chamber and opening into one of the end walls thereof;
c) a liquid outlet in open communication with the chamber, this outlet extending tangentially out of said chamber;
d) a rotary impeller rotatably mounted within the chamber, said impeller comprising one disc extending close to the end wall which is opposite to the one in which the liquid inlet opens;
e) a power shaft coaxial with and rigidly connected to the one disc so as to rotate the impeller in a given direction within the chamber;
f) a gas feed pipe coaxial with and rigidly connected to the impeller so as to rotate therewith, the gas feed pipe having a gas inlet located outside the casing; and
g) at least one gas injector pipe rigidly connected to the gas feed pipe so as to rotate in unison therewith and with the impeller to which the gas feed pipe is connected, this at least one injector pipe being perpendicular to the feed pipe and extending radially within the casing, the at least one injector pipe having one end in open communication with the gas outlet of the feed pipe and another radially opposite end defining a gas nozzle opening within the casing at a radial distance away from the gas feed pipe that is shorter than the radius of the one disc.

[0017] In accordance with the invention, this pump is characterized in that:

h) its rotary impeller comprises an other disc of the same radius as the one disc previously mentioned, both discs being coaxial with the chamber and this other disc being rigidly connected to the one disc and extending at such a distance away from the one disc as to be close to the end wall into which the liquid inlet opens, the other disc having a central opening to allow the liquid fed through the inlet to enter the chamber;
i) the one disc and the other disc of the rotary impeller have opposite flat surface which face each other and on which a plurality of ribs extend;
j) the power shaft extends out of the casing in a direction opposite to the liquid inlet;
k) the gas inlet of the gas feed pipe is connected though a rotary seal joint to a pressurized gas source; and
l) the at least one gas injector pipe extends within the casing at mid-distance between the discs of the impeller.

[0018] As a result, the centrifugal pump according to the invention can pump the liquid at a pressure of more than 550 kN/m^2 with a flow rate as high as 190 m^3/h while simultaneously allowing injection and dissolution of up to 15% by volume of gas into the liquid.

[0019] As can be appreciated, the gas injection assembly used in accordance with the invention is of very simple structure and can be incorporated into the structure of a centrifugal pump of conventional structure without any major modification to be made in the same.

[0020] The gas feed pipe may be incorporated to the power shaft to form a unitary structure. Preferably, however, the gas feed pipe is separate from the power shaft and extends coaxially through both the liquid inlet and the opening of the other disc of the impeller in a direction opposite to the power shaft. This is particularly interesting since the gas feed pipe then enters the pump through its inlet and thus does not call for any additional opening to be made in the casing of the pump.

[0021] As can be noted, the injector pipes extend radially between the discs within the impeller. Thus, there is no need for openings, slots or internal passages to be made in the discs or other components of the rotor. As a result, the investment and maintenance costs are reduced to a minimum.

[0022] In accordance with a first preferred embodiment of the invention, the ribs extending on the opposite flat surfaces of the discs are connected to each other and form vanes that extend radially outwardly away from the opening made in the one disc in such a manner as not to interfere with the gas injector pipes extending between the discs.

[0023] In accordance with a second preferred embodiment of the invention, the ribs extending on the opposite flat surface of the discs project away from their respective discs at such a distance as to leave a gap in between and then to give room to the gas injector pipes. In such case, the ribs are preferably thick and high, volute-shaped and radially outwardly curved in a direction opposite to the direction in which the impeller is rotated. In such a case, the pump has the main advantage of leaving a gap between the discs through which

large particles in suspension in the pumped liquid may pass.

[0024] As can be appreciated, the above described centrifugal pump with its incorporated gas injection assembly can be used to inject any kind of gas into any kind of liquid while the same is being pumped. A preferred application of the invention is however to use the above combination to inject air into clarified or waste water.

[0025] As can also be appreciated, the length of the gas injector pipes may vary depending on the application. The shorter are the gas injector pipes, the lower will be the pressure required for injecting air into the pump. However, the longer are the gas injectors, the higher will be the pressure required for injecting air and consequently the amount of air injected into the pump.

[0026] Tests carried out by the Applicant have shown that a centrifugal pump of the rotary disc type as disclosed hereinabove incorporating a gas injection assembly as also disclosed hereinabove could easily build up a pressure of 550 to 970 kN/m^2 (80 to 140 lbs) and allow injection and dissolution of to 15% by volume of air into the pump water, thereby allowing the formation of very efficient micro-bubbles of a few tenths of a micron. Moreover, the flow rate of the pump was appropriate and the energy consumption much better than expected (more than 2m^3/HP).

[0027] In accordance with the invention, there is also provided a very efficient yet simple method for injecting and dissolving a gas, especially air, into a liquid like waste or clarified water while this liquid is being pumped with a centrifugal pump according to the invention as defined hereinabove. This method which is particularly interesting in that it calls for standard components readily available to anyone to carry it out, is characterized in that the gas to be injected and dissolved is fed under pressure through the gas injector pipe(s) extending radially in the gap left between the one and other discs of the rotary impeller while said impeller is rotated by the power shaft.

[0028] Once again, the gas is preferably air and the liquid waste or clarified water even though this method could be used with other gas and liquids.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The invention and its advantages will be better understood upon reading the following, non-restrictive descrition of two preferred embodiments thereof, made with reference to the accompanying drawings in which:

Fig. 1 is a side elevational view, partly in cross-section, of a centrifugal pump of the rotary disc type, incorporating a gas injection assembly according to the invention;

Fig. 2 is an exploded perspective view of the casing, the impeller and the gas injection assembly of the pump shown in Fig. 1;

Fig. 3 is a side elevational view, partly in cross-section, of a centrifugal pump of the bladed-impeller type, incorporating a gas injection assembly according to the invention; and

Fig. 4 is a diagram giving the pressure as a function of the flow rate in a pump like the one shown in Fig. 1, with and without injection of air.

DESCRIPTION OF TWO PREFERRED EMBODIMENTS

[0030] In the following description, reference will be made exclusively to water as the liquid to be pumped and air as the gas to he injected into the pumped liquid. It is worth mentioning however that the invention is not restricted to the injection of air into water, especially waste or clarified water, and may actually be used to inject other gases into other liquids.

[0031] The centrifugal liquid pump 1 used in accordance with a first embodiment of the invention shown in Figs. 1 and 2, is of the "rotary disc" type. It comprises a casing 3 defining an inner, substantially cylindrical chamber 5 having a pair of opposite end walls 7, 9 coaxial with each other. The casing 3 is provided with a liquid inlet 11 that is coaxial with the chamber 5 and opens into one of the opposite end walls, e.g. the one numbered 7. The casing 3 also comprises a liquid outlet 13 that is in open communication with the chamber 5 and extends tangentially out of the same.

[0032] A rotary impeller 15 is rotatably mounted within the chamber 5. This impeller 15 comprises a pair of spaced apart discs 17, 19 of a given radius that are coaxial with the chamber. The discs 17, 19 are connected to each other by a plurality of small rods 22 at such a distance away from each other as to extend close to the opposite end walls, respectively. The disc 17 that is located adjacent the opposite end wall 7 into which the liquid inlet opens, has a central opening 21 to allow the liquid injected through the inlet 11 to enter the chamber 5. Both discs 17, 19 have flat surfaces which face each other and on which a plurality ribs 23 extend. As is clearly shown in Fig. 1, the ribs 23 project from the discs at such a distance as to leave a gap in between. As is better shown in Fig. 2, the ribs 23 are thick and high, volute-shaped and curved radially outwardly in a direction opposite to the direction in which the impeller is rotated, to increase as much as possible the friction between the discs and water that is pumped and thus the pressure that can be built up within the pump.

[0033] The pump 1 also comprises a power shaft 25 coaxial with and rigidly connected to the disc 19 that is opposite to the perforated one. The power shaft is operatively mounted into a bearing assembly 27 and connected to a motor (not shown) via a set of pulleys 29 so as to rotate the impeller 15 within the chamber 5. As is shown, the power shaft 25 extends out of the casing in a direction opposite to the liquid inlet 21.

[0034] In accordance with the invention, the above

pump 1 is improved in that it incorporates a gas-injection assembly 31 for use to inject and dissolve, at least in part, a gas, especially air, into the liquid while the same is being pumped.

[0035] Referring again to Figs. 1 and 2, the assembly 31 comprises a gas feed pipe 33 coaxial with and rigidly connected to the impeller 15 so as to rotate therewith. The gas feed pipe 33 has a straight portion that extends coaxially through both the liquid inlet 11 and the opening 21 of the disc 17 of the impeller in a direction opposite to the power shaft 25. The end 35 of this straight portion is detachably fixed to the middle of the disc 19 which is already connected to the power shaft 25, thereby causing the requested rigid connection of this feed pipe to the impeller. The gas feed pipe 33 also has another, opposite end defining a gas inlet, which is located outside the casing and operatively connected via a rotary seal joint 37 to a pressurized gas source 39.

[0036] The assembly 31 also comprises one or more gas injector pipes 41 rigidly connected to the gas feed pipe near its end 35 so as to rotate in unison therewith and with the impeller 15. When there is one gas injector pipe 41, a counterweight must be provided onto the gas feed pipe 33 to balance the same when it rotates with the impeller. To avoid the use of a counterweight and simultaneously improve the distribution to gas into the liquid that is pumped, use is preferably made of more than one gas injector pipes 41, which are identical in shape and length and symmetrically positioned all around the gas feed pipe 33 so as to extend in a same plane parallel to the discs and be in open communication with the same gas outlet provided in the feed pipe near its end 35. Of course, the number of gas injector pipes 41 that can be used depends on the size of the pump. In practice, use can be made of 3 to 5 injector pipes that are preferably detachably connected to the feed pipe 33 by means known per se, to make their installation and maintenance easier to carry out.

[0037] As is shown, each injector pipe 41 is perpendicular to the feed pipe 33 and extends radially within the casing 5 between the ribs 23 of the discs of the impeller. Each injector pipe 41 also has one end in open gas communication with the feed pipe 33 and another radially, opposite end 43 defining a gas nozzle, which opens within the casing between the discs 17, 19 at a radial distance away from the feed pipe 33 that is shorter than the radius of the discs.

[0038] As already explained hereinabove, the length of the gas injector pipes may vary depending on the application. The shorter are the gas injector pipes, the lower will be pressure required for injecting air into the pump. However, the longer are the gas injectors, the higher will be the pressure required for injecting air and consequently the amount of air injected into the pump.

[0039] The shape and diameter of the gas injector pipes may also vary depending on the application. Thus, instead of being straight, they could be curved. Similarly, instead of having only one opening at their opposite ends, the injector pipes could have a plurality of openings over their length.

[0040] Fig. 3 of the drawings shows another embodiment of the invention, which is very similar to the one previously disclosed except that the pump comprises vanes instead of ribs. For the purpose of simplicity, the same reference numerals have been used for identifying the same structural components.

[0041] In this other embodiment, the impeller 15 also comprises a pair of spaced apart discs 17, 19. However, instead of being connected by rods and provided with ribs, these discs are connected by blades or vanes 23' that are preferably curved and extend radially outwardly away from the opening 21 made in the disc 17 in such a manner as not to interfere with the gas injector pipes 41 that extend between the discs. For this purpose, the injector pipes 41 may be positioned between adjacent vanes 23'.

[0042] In the embodiment of Fig. 3, the liquid inlet 11 is L-shaped and the gas feed pipe 33 has its straight portion long enough to extend out of the L-shaped inlet 11 and be connected to the rotary seal joint 37 out of the same. This makes the maintenance of the rotary seal joint 37 much easier to carry out, as the operator has a direct access to it.

[0043] A pump of the rotary-disc type like the one shown in Figs. 1 and 2 was extensively tested by the Applicant for the recirculation of clarified water in a huge, industrial clarifier.

[0044] The diameter of the discs of the tested pump was equal to 35 cm and their spacing equal to 6 cm. Each disc had five ribs 2 cm high. Three air injector pipes were used, whose length was 10 cm. These injector pipes did not interfere whatsoever with the liquid flow. The impeller was rotated at 2100 rpm.

[0045] The results that were obtained are reported in the diagram shown in Fig. 4. As can be seen, a pressure of more than 550 kN/m^2 was easily built up, with a flow rate as high as 190 m^3/h. Moreover, up to 15% of air was easily injected into the pumped water, without unduly affecting the efficiency of the pump, using an air pressure source of 200 kN/m^2 only.

Claims

1. A centrifugal pump (1) for use to pump a liquid and simultaneously inject a gas into this liquid while it is pumped, said pump comprising:

   a) a casing (3) defining an inner, substantially cylindrical chamber (5), said chamber having a pair of opposite end walls (7, 9) coaxial with each other;
   b) a liquid inlet (11) in open communication with the chamber (5), said inlet being coaxial with said chamber and opening into one (17) of the end walls thereof;
   c) a liquid outlet (13) in open communication

with the chamber (5), said outlet extending tangentially out of said chamber;

d) a rotary impeller (15) rotatably mounted within the chamber (5), said impeller comprising one disc (19) extending close to the end wall (9) which is opposite to the one in which the liquid inlet (11) opens;

e) a power shaft (25) coaxial with and rigidly connected to the one disc (19) so as to rotate the impeller (15) in a given direction within the chamber;

f) a gas feed pipe (33) coaxial with and rigidly connected to the impeller (15) so as to rotate therewith, said gas feed pipe having a gas inlet located outside said casing; and

g) at least one gas injector pipe (41) rigidly connected to the gas feed pipe (33) so as to rotate in unison therewith and with the impeller (15) to which said gas feed pipe is connected, said at least one injector pipe (41) being perpendicular to said feed pipe and extending radially within said casing, said at least one injector pipe having one end in open communication with the gas outlet of the feed pipe and another radially opposite end (43) defining a gas nozzle opening within the casing at a radial distance away from said gas feed pipe (33), said radial distance being shorter than the radius of the one disc (19);

characterized in that

h) the rotary impeller (15) of said centrifugal pump comprises an other disc (17) of the same radius as the one disc (19), both discs being coaxial with the chamber and said other disc (17) being rigidly connected to the one disc (19) and extending at such a distance away from said one disc (19) as to be close to the end wall (7) into which the liquid inlet (11) opens, said other disc (17) also having a central opening (21) to allow the liquid injected through said inlet to enter the chamber (5);

i) the one disc and the other disc (17, 19) have opposite flat surfaces which face each other and on which a plurality of ribs (23, 23') extend;

j) the power shaft (25) extends out of the casing (3) in a direction opposite to the liquid inlet (11);

k) the gas inlet of the gas feed pipe (33) is connected though a rotary seal joint (37) to a pressurized gas source (39); and

l) said at least one gas injector pipe (41) extends within said casing at mid-distance between the one and other discs (17, 19) of the impeller;

whereby said centrifugal pump can pump the liquid at a pressure of more than 550 kN/m^2 with a flow rate as high as 190 m^3/h while simultaneously allowing injection and dissolution of up to 15% by volume of gas into the liquid.

2. The centrifugal pump of claim 1, characterized in that it comprises a plurality of said gas injector pipes (41) which are identical in shape and are symmetrically positioned all around said gas feed pipe (33) so as to extend in a same plane parallel to the one disc and the other disc (17, 19) and to be in open communication with the gas outlet (35) of the feed pipe.

3. The centrifugal pump of claim 2, characterized in that it comprises three to five of said injector pipes (41).

4. The centrifugal pump of claim 2 or 3, wherein the ribs extending on the opposite flat surfaces of the one and other discs (17, 19) are connected to each other to form vanes (23") that extend radially outwardly away from the opening made in the other disc (17) in such a manner as not to interfere with the gas injector pipes (41) extending between said one and other discs.

5. The centrifugal pump of claim 2 or 3, characterized in that the ribs (23) extending on the opposite flat surfaces of the one and other discs (17, 19) project from said discs at such a distance as to leave a gap in between and then to give room to the gas injector pipes (41), said one and other discs (17, 19) of the impeller (15) being then connected to each other by a plurality of rods (22).

6. The centrifugal pump of claim 5, characterized in that the ribs (23) are volute-shaped and radially outwardly curved in a direction opposite to the given direction in which said impeller (15) is rotated.

7. The centrifugal pump of any one of claims 1 to 6, characterized in that the gas feed pipe (33) extends coaxially through both the liquid inlet (11) and the opening (21) of the other disc (17) of the impeller (15) in a direction opposite to the power shaft (25), said gas feed pipe (33) having one end defining said gas outlet (35) which is detachably fixed to the one disc (19) to which is already connected the power shaft (25) thereby causing said rigid connection of said feed pipe to said impeller (15), said gas feed pipe also having another opposite end defining said gas inlet which is operatively connected to said rotary seal joint (37).

8. The centrifugal pump of claim 7, characterized in that the liquid inlet (11) is L-shaped and the gas feed pipe (33) has its opposite end that extends out of said L-shaped inlet and is connected to the rotary seal joint (37) out of said L-shaped inlet.

9. The centrifugal pump of any one of claims 1 to 8, characterized in that the gas feed pipe (33) is incorporated to the power shaft (25).

10. The centrifugal pump of any one of claims 1 to 9, characterized in that the radial distance at which projects away the end (43) of said at least one injector pipe (41) is much shorter than the radius of said first and second discs (17, 19).

11. The use of an improved centrifugal pump as defined in any one of claims 1 to 10, for injecting air into waste or clarified water while the same is being pumped.

12. A method for injecting and dissolving a gas into a liquid while said liquid is being pumped in a centrifugal pump (1) as claimed in any one of claims 1 to 10, characterized in that the gas to be injected and dissolved is fed under pressure through said at least one gas injector pipe (41) extending radially in the gap left between the one and other discs (17, 19) of the rotary impeller (15) while said impeller (15) is rotated by the power shaft (25).

13. The method of claim 12, characterized in that said gas is air and said liquid is waste or clarified water.

Patentansprüche

1. Kreiselpumpe (1) zum Pumpen einer Flüssigkeit und zum gleichzeitigen Einblasen eines Gases in diese Flüssigkeit, während sie gepumpt wird, umfassend:

a) ein Gehäuse (3), das eine innere, im wesentlichen zylindrische Kammer (5) definiert und die Kammer ein Paar gegenüberliegender Stirnwände (7, 9) aufweist, die koaxial angeordnet sind,
b) einen Flüssigkeitseinlaß (11), der in offener Verbindung zur Kammer (5) steht, der koaxial mit der Kammer angeordnet ist und sich in eine (17) der Stirnwände öffnet,
c) einen Flüssigkeitsauslaß (13), der in offener Verbindung zur Kammer (5) steht und der sich tangential aus der Kammer heraus erstreckt,
d) ein Flügelrad (15), das drehbar innerhalb der Kammer (5) angebracht ist und eine Scheibe (19) aufweist, die sich nahe der Stirnwand (9) befindet, die sich gegenüber derjenigen befindet, in die sich der Flüssigkeitseinlaß (11) öffnet,
e) eine Antriebswelle (25), die koaxial mit Scheibe (19) angeordnet und mit dieser fest verbunden ist, um das Flügelrad (15) in einer vorgegebenen Richtung innerhalb der Kammer zu drehen,
f) ein Gaszuführungsrohr (33), das koaxial mit dem Flügelrad (15) angeordnet und mit diesem fest verbunden ist, um gemeinsam mit diesem zu rotieren, und das Gaszuführungsrohr einen Gaseinlaß aufweist, der sich außerhalb des Gehäuses befindet, und

g) mindestens ein Gas-Einblasrohr (41), das fest mit dem Gaszuführungsrohr (33) verbunden ist, um sich zusammen mit diesem und dem Flügelrad (15), mit dem das Gaszuführungsrohr verbunden ist, zu drehen, sich mindestens ein senkrecht zum Zuführungsrohr angeordnetes Einblasrohr (41) radial innerhalb des Gehäuses erstreckt, und ein Ende dieses Einblasrohrs in offener Verbindung zum Gasauslaß des Gasversorgungsrohrs steht und das andere Ende (43), das sich radial gegenüber befindet, eine Gasdüsenöffnung innerhalb des Gehäuses in einem radialen Abstand vom Gaszuführungsrohr (33) definiert, wobei der radiale Abstand kleiner als der Radius der einen Scheibe (19) ist,
dadurch **gekennzeichnet**, daß
h) das Flügelrad (15) der Kreiselpumpe eine weitere Scheibe (17) mit dem gleichen Radius der einen Scheibe (19) umfaßt, beide Scheiben koaxial zur Kammer angeordnet sind und die andere Scheibe (17) fest mit der einen Scheibe (19) verbunden ist und sich in einer solchen Entfernung zur einen Scheibe (19) erstreckt, so daß sie sich nahe der Stirnwand (7) befindet, in die sich der Flüssigkeitseinlaß (11) öffnet, wobei die andere Scheibe (17) zusätzlich eine zentrale Öffnung (21) aufweist, um den Eintritt der Flüssigkeit, die durch den Einlaß eingebracht wird, in die Kammer (5) zu ermöglichen,
i) die eine Scheibe und die andere Scheibe (17, 19) gegenüberliegende flache Oberflächen aufweisen, die einander zugewandt sind und auf denen mehrere Rippen (23, 23') verlaufen,
j) die Antriebswelle (25) in entgegengesetzter Richtung zum Flüssigkeitseinlaß (11) aus dem Gehäuse (3) herausragt,
k) der Gaseinlaß des Gaszuführungsrohrs (33) über ein dichtes Drehgelenk (37) mit einer Druckgasquelle (39) verbunden ist, und
l) sich mindestens ein Gas-Einblasrohr (41) innerhalb des Gehäuses in der Mitte zwischen der einen und der anderen Scheibe (17, 19) des Flügelrades erstreckt,

wobei die Kreiselpumpe Flüssigkeit bei einem Druck von mehr als 550 kN/m^2 mit einer Durchflußrate von bis zu 190 m^3 / h pumpen kann und gleichzeitig das Einblasen und Lösen von bis zu 15 Vol.% des Gases in die Flüssigkeit zuläßt.

2. Kreiselpumpe nach Anspruch 1, dadurch gekenn-

zeichnet, daß sie mehrere Gas-Einblasrohre (41) umfaßt, die identisch geformt sind und symmetrisch um das Gaszuführungsrohr (33) angeordnet sind, so daß sie sich in der gleichen Ebene parallel zur einen und zur anderen Scheibe (17, 19) erstrecken und sich in offener Verbindung mit dem Gasauslaß (35) des Zuführungsrohres befinden.

3. Kreiselpumpe nach Anspruch 2, dadurch gekennzeichnet, daß sie drei bis fünf der Einblasrohre (41) umfaßt.

4. Kreiselpumpe nach Anspruch 2 oder 3, wobei die Rippen, die an den gegenüberliegenden flachen Oberflächen der einen und der anderen Scheibe (17, 19) verlaufen, jeweils miteinander verbunden sind, um Radschaufeln (23") zu bilden, die so von der Öffnung in der anderen Scheibe (17) her radial nach außen verlaufen, daß sie nicht mit den Gas-Einblasrohren (41) zusammentreffen, die sich zwischen der einen und der anderen Scheibe erstrekken.

5. Kreiselpumpe nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß die Rippen (23), die an den gegenüberliegenden flachen Oberflächen der einen und der anderen Scheibe (17, 19) verlaufen, so weit von den Scheiben hervorstehen, daß ein dazwischenliegender Spalt bleibt, um Raum für die Gas-Einblasrohre (41) zu lassen, und die eine und die andere Scheibe (17, 19) des Flügelrades (15) über mehrere Stäbe (22) miteinander verbunden sind.

6. Kreiselpumpe nach Anspruch 5, dadurch gekennzeichnet, daß die Rippen (23) schneckenförmig sind und radial nach außen entgegen der Drehrichtung, in die das Flügelrad (15) gedreht wird, gekrümmt sind.

7. Kreiselpumpe nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß sich das Gaszuführungsrohr (33) koaxial, aber in entgegengesetzter Richtung zur Antriebswelle (25) sowohl durch den Flüssigkeitseinlaß (11) und die Öffnung (11) der anderen Scheibe (17) des Flügelrades (15) erstreckt, ein Ende des Gaszuführungsrohrs (33) einen Gasauslaß (35) darstellt, der lösbar an der einen Scheibe (19) befestigt ist, die bereits mit der Antriebswelle (25) verbunden ist, und dabei eine feste Verbindung zwischen dem Versorgungsrohr und dem Flügelrad (15) begründet und daß das andere gegenüberliegende Ende des Gasversorgungsrohres den Gaseinlaß darstellt, der sich im Eingriff mit dem dichten Drehgelenk (37) befindet.

8. Kreiselpumpe nach Anspruch 7, dadurch gekennzeichnet, daß der Flüssigkeitseinlaß (11) L-förmig ist und das gegenüberliegende Ende des Gaszuführungsrohrs (33) aus diesem L-förmigen Einlaß herausragt und aus dem L-förmigen Einlaß heraus mit dem dichten Drehgelenk (37) verbunden ist.

9. Kreiselpumpe nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß das Gaszuführungsrohr (33) in die Antriebswelle (25) integriert ist.

10. Kreiselpumpe nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, daß der radiale Abstand, in dem das Ende (43) des mindestens einen Einblasrohrs (41) herausragt, wesentlich kleiner als der Radius der ersten und zweiten Scheibe (17, 19) ist.

11. Verwendung einer verbesserten Kreiselpumpe nach einem der Ansprüche 1 bis 10 zum Einblasen von Luft in verschmutztes oder geklärtes Wasser beim Pumpen des Wassers.

12. Verfahren zum Einblasen und Auflösen eines Gases in einer Flüssigkeit, während die Flüssigkeit in einer Kreiselpumpe (1), die einem der Ansprüche 1 bis 10 entspricht, gepumpt wird, dadurch gekennzeichnet, daß das einzublasende und aufzulösende Gas unter Druck durch mindestens ein Gas-Einblasrohr (41) eingeblasen wird, das sich in den Spalt hereinragt, der zwischen der einen und der anderen Scheibe (17, 19) des Flügelrades (15) verläuft, während das Flügelrad (15) von der Antriebswelle (25) gedreht wird.

13. Verfahren nach Anspruch 12, dadurch gekennzeichnet, daß das Gas Luft ist und die Flüssigkeit verschmutztes oder geklärtes Wasser ist.

Revendications

1. Une pompe centrifuge (1) pour pomper un liquide et simultanément injecter un gaz dans ce liquide pendant qu'il est pompé, cette pompe comprenant:

(a) un boîtier (3) définissant une chambre intérieure substantiellement cylindrique (5), ladite chambre ayant une paire de parois d'extrémités opposées coaxiales l'une à l'autre;
(b) une entrée de liquide (11) en communication ouverte avec la chambre (5), ladite entrée étant coaxiale à ladite chambre et ouvrant dans une (17) des parois d'extrémité de celle-ci;
(c) une sortie de liquide (13) en communication ouverte avec la chambre (5), ladite sortie s'étendant tangentiellement hors de ladite chambre;
(d) une turbine (15) montée en rotation dans la chambre (5), ladite turbine comprenant un disque (19) s'étendant près de la paroi d'extrémité

(9) qui est opposée à celle dans laquelle l'entrée de liquide (11) débouche;

(e) un arbre d'entraînement (25) relié rigidement et coaxialement au premier disque (19) pour tourner la turbine (15) dans une direction donnée à l'intérieur de la chambre;

(f) un tuyau d'alimentation en gaz (33) relié rigidement et coaxialement à la turbine (15) de façon à tourner avec celle-ci, ledit tuyau d'alimentation en gaz ayant une entrée de gaz située à l'extérieur dudit boîtier; et

(g) au moins un tuyau d'injection de gaz (41) relié rigidement au tuyau d'alimentation de gaz (33) de façon à tourner simultanément avec celui-ci et avec la turbine (15) à laquelle ledit tuyau d'alimentation de gaz est relié, ledit au moins un tuyau d'injection de gaz (41) étant perpendiculaire audit tuyau d'alimentation et s'étendant radialement dans ledit boîtier, ledit au moins un tuyau d'injection ayant une extrémité en communication ouverte avec la sortie (35) de gaz du tuyau d'alimentation et une autre extrémité radialement opposée (43) définissant une buse de sortie de gaz ouvrant dans le boîtier à une distance radiale dudit tuyau d'alimentation en gaz (33), ladite distance radiale étant plus courte que le diamètre du premier disque (19),

caractérisée en ce que:

(h) la turbine (15) de ladite pompe centrifuge comprend un autre disque (17) ayant le même rayon que le premier disque (19), les deux disques étant coaxiaux dans la chambre et ledit autre disque (17) étant fixé rigidement au premier disque (19) et s'étendant à une telle distance dudit premier disque (19) qu'il se trouve prêt de la paroi d'extrémité (7) dans laquelle l'entrée de liquide (11) ouvre, ledit autre disque (17) ayant aussi une ouverture centrale (21) pour permettre au liquide injecté par ladite entrée de pénétrer dans la chambre (5);

(i) le premier disque et l'autre disque (17, 19) ont des surfaces opposées planes qui se font face l'une à l'autre et sur lesquelles une pluralité de nervures (23, 23') sont disposées;

(j) l'arbre d'entraînement (25) s'étend hors du boîtier (3) dans une direction opposée à l'entrée de liquide (11);

(k) l'entrée de gaz du tuyau d'alimentation en gaz (33) est connectée au moyen d'un joint d'étanchéité rotatif (37) à une source de gaz sous pression (39); et

(l) ledit au moins un tuyau d'injection de gaz (41) s'étend dans ledit boîtier à mi-distance entre le premier et l'autre disque (17, 19) de la turbine;

grâce à quoi ladite pompe centrifuge peut ainsi pomper le liquide à une pression de plus de 550 k/m^2 avec un débit aussi élevé que 190 m^3/h tout en permettant simultanément l'injection et la dissolution de jusqu'à 15% en volume de gaz dans le liquide.

2. La pompe centrifuge de la revendication 1, caractérisée en ce qu'elle comprend une pluralité desdits tuyaux d'injection de gaz (41) qui sont identiques en forme et sont positionnés symétriquement tout autour dudit tuyau d'alimentation en gaz (33) de façon à s'étendre dans un même plan parallèle au premier disque et à l'autre disque (17,19) et être en communication ouverte avec la sortie de gaz (35) dudit tuyau d'alimentation.

3. La pompe centrifuge de la revendication 2, caractérisée en ce qu'elle comprend trois à cinq desdits tuyaux d'injection de gaz (41).

4. La pompe centrifuge de la revendication 2 ou 3, caractérisée en ce que les nervures s'étendant sur les surfaces opposées planes du premier et de l'autre disque (17,19) sont reliées l'une à l'autre pour former des pales (23") qui s'étendent radialement vers l'extérieur depuis l'ouverture faite dans l'autre disque (17) de telle façon à ne pas interférer avec les tuyaux d'injection de gaz (41) s'étendant entre lesdits premier et autre disque.

5. La pompe centrifuge de la revendication 2 ou 3, caractérisée en ce que les nervures (23) s'étendant sur les surfaces opposées planes du premier et autre disque (17,19) s'étendent au-dessus des disques à une distance telle qu'un espace est laissé entre elles pour ainsi permettre le passage aux tuyaux d'injection de gaz (41), lesdits prémier et autre disques (17,19) de la turbine (15) étant alors reliés l'un à l'autre au moyen d'une pluralité de tiges (22).

6. La pompe centrifuge de la revendication 5, caractérisée en ce que les nervures (23) ont une forme en spirale et sont courbées radialement vers l'extérieur dans une direction opposée à la direction donnée dans laquelle ladite turbine (15) est entrainée en rotation.

7. La pompe centrifuge de l'une quelconque des revendication 1 à 6, caractérisée en ce que le tuyau d'alimentation en gaz (33) s'étend coaxialement dans à la fois l'entrée de liquide (11) et l'ouverture (21) de l'autre disque (17) de la turbine (15) dans une direction opposée à l'arbre d'entraînement (25), ledit tuyau d'alimentation en gaz (33) ayant une extrémité définissant ladite sortie de gaz (35) qui est fixée de façon détachable au premier disque (19) auquel est déjà relié l'arbre d'entraînement (25) de façon à ainsi causer ladite connexion rigide

entre ledit tuyau d'alimentation et ladite turbine (15), ledit tuyau d'alimentation en gaz ayant aussi une autre extrémité opposée définissant ladite entrée de gaz, qui est reliée de façon opérationnelle audit joint d'étanchéité rotatif (37).

8. La pompe centrifuge de la revendication 7, caractérisée en ce que l'entrée de liquide (11) a la forme d'un L et le tube d'alimentation en gaz (33) a son extrémité opposée qui s'étend hors de ladite entrée en forme de L et est reliée au joint d'étanchéité rotatif (37) hors de ladite entrée en forme de L.

9. La pompe centrifuge de l'une quelconque des revendications 1 à 8, caractérisée en ce que le tuyau d'alimentation en gaz (33) est incorporé à l'arbre d'entraînement (25).

10. La pompe centrifuge de l'une quelconque des revendications 1 à 9, caractérisée en ce que la distance radiale à laquelle s'étend l'extrémité (43) dudit au moins un tuyau d'injection (41) est beaucoup plus courte que le rayon desdits premier et second disques (17,19).

11. L'utilisation de la pompe centrifuge perfectionnée telle que définie dans l'une quelconque des revendications 1 à 10 pour injecter de l'air dans l'eau usée ou clarifiée pendant que ces eaux sont pompées.

12. Une méthode pour injecter et dissoudre un gaz dans un liquide tandis que ledit liquide est entrain d'être pompé dans une pompe centrifuge (1) telle que revendiquée dans l'une quelconque des revendications 1 à 10, caractérisée ce que le gaz à injecter et dissoudre est alimenté sous pression à travers ledit au moins un tuyau d'injection de gaz (41) s'étendant radialement dans l'espace libre laissé entre le premier et l'autre disque (17,19) de la turbine (15) pendant que ladite turbine (15) est entraînée en rotation par l'arbre d'entraînement (25).

13. La méthode de revendication 12, caractérisée en ce que ledit gaz est de l'air et ledit liquide est de l'eau usée ou clarifiée.

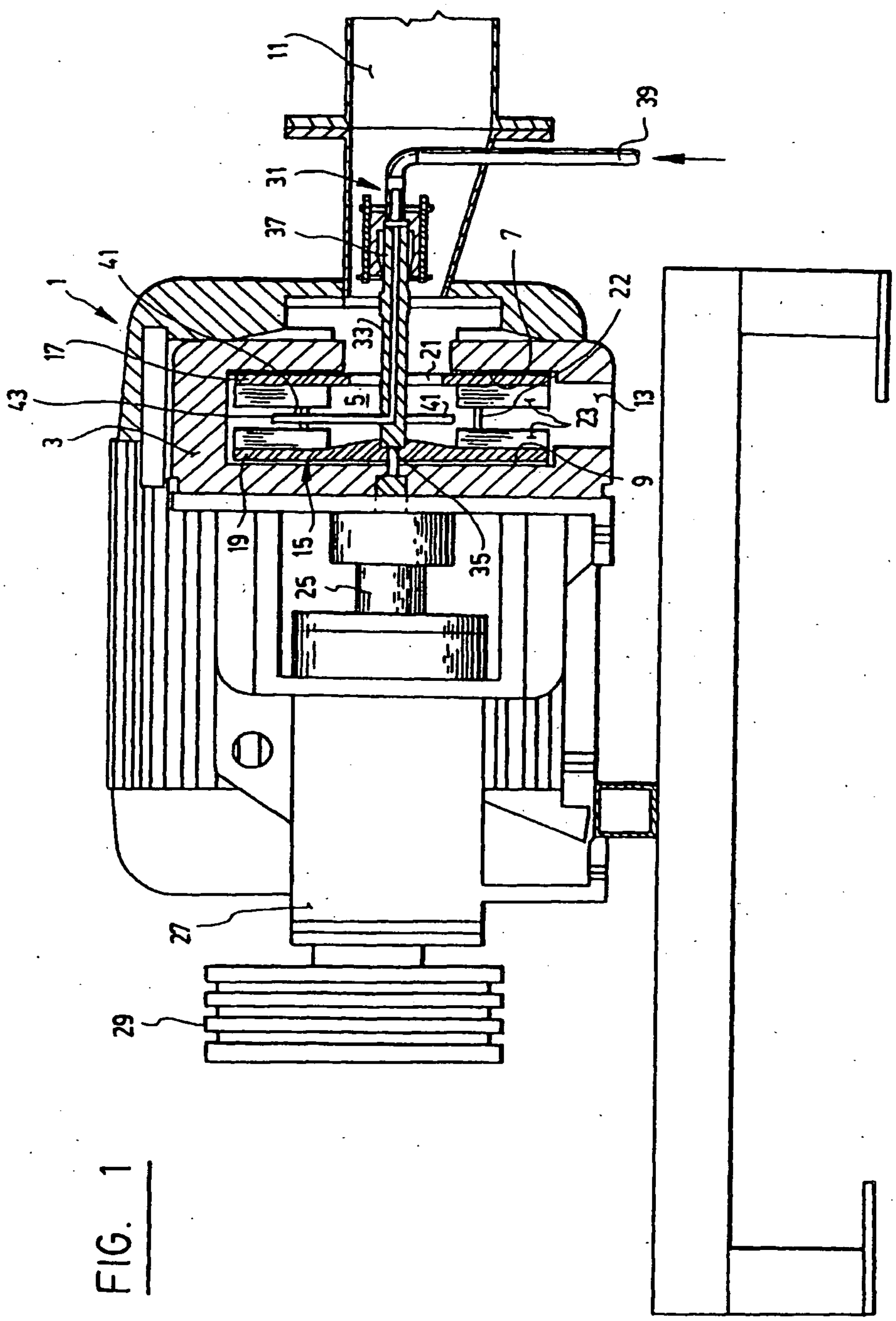

FIG. 1

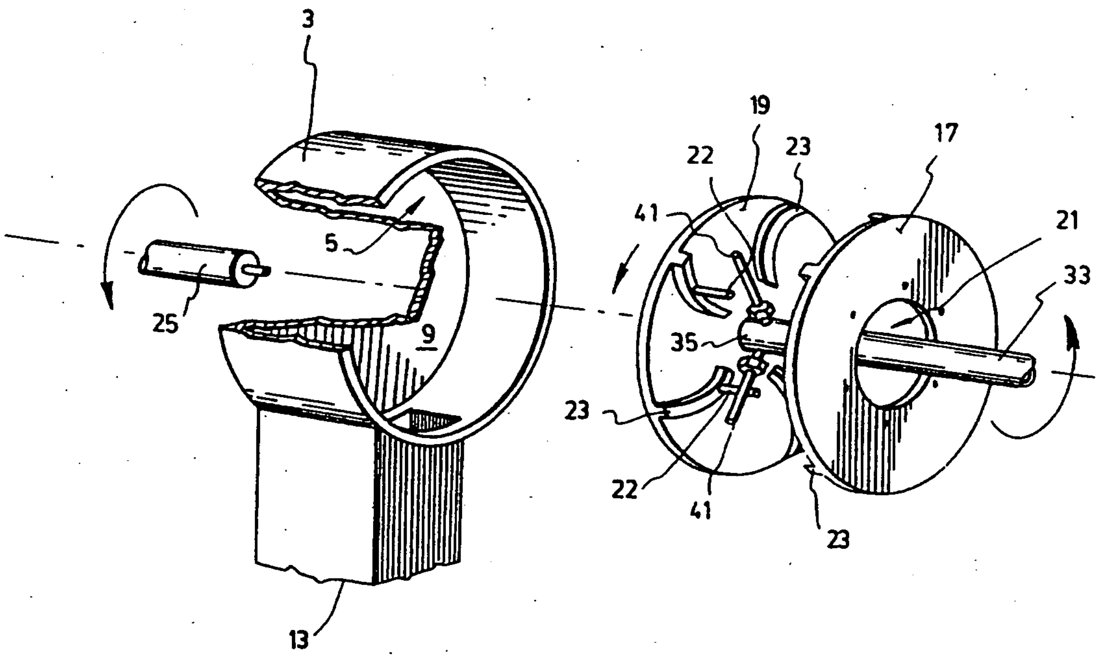

FIG. 2

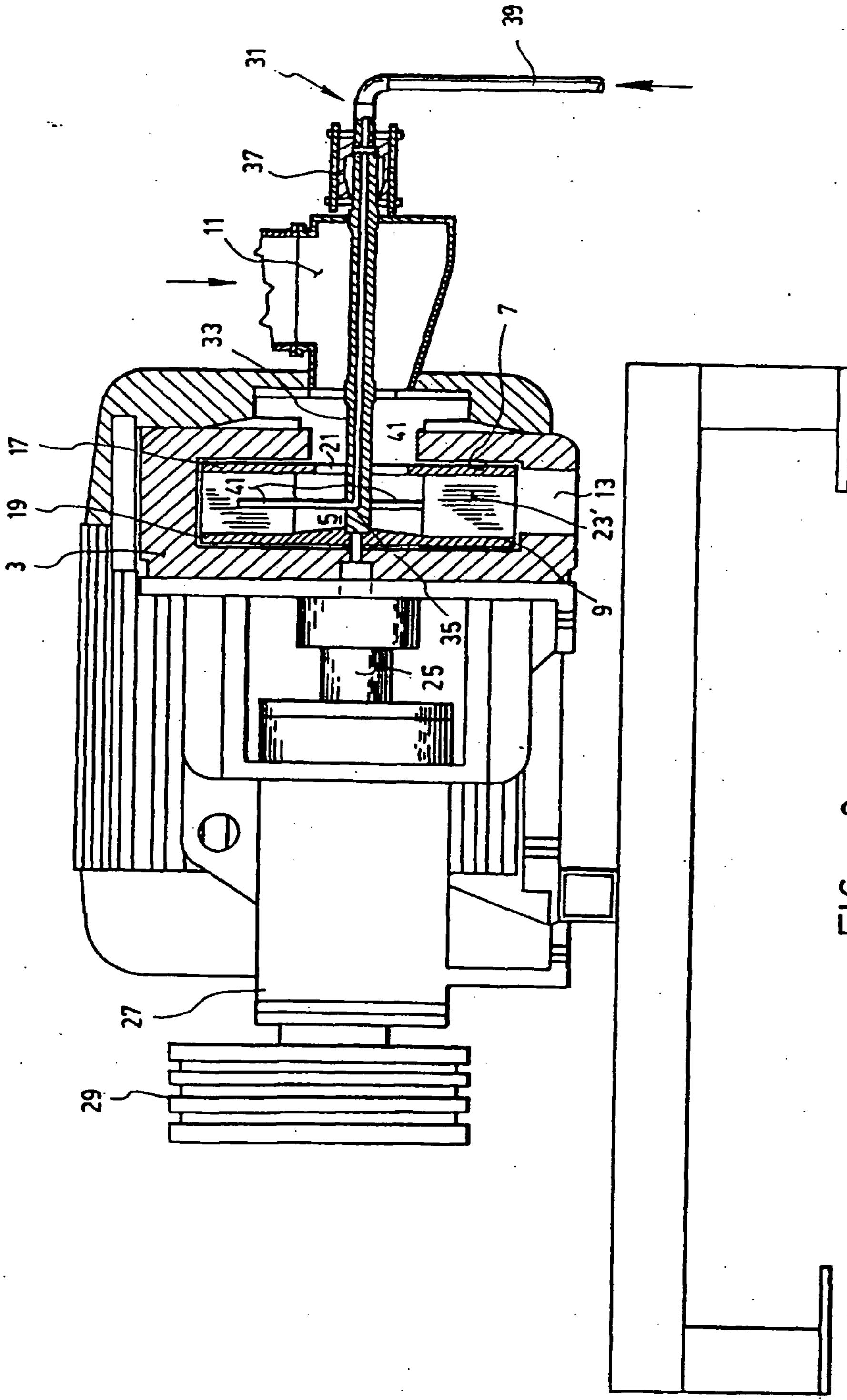

FIG. 3

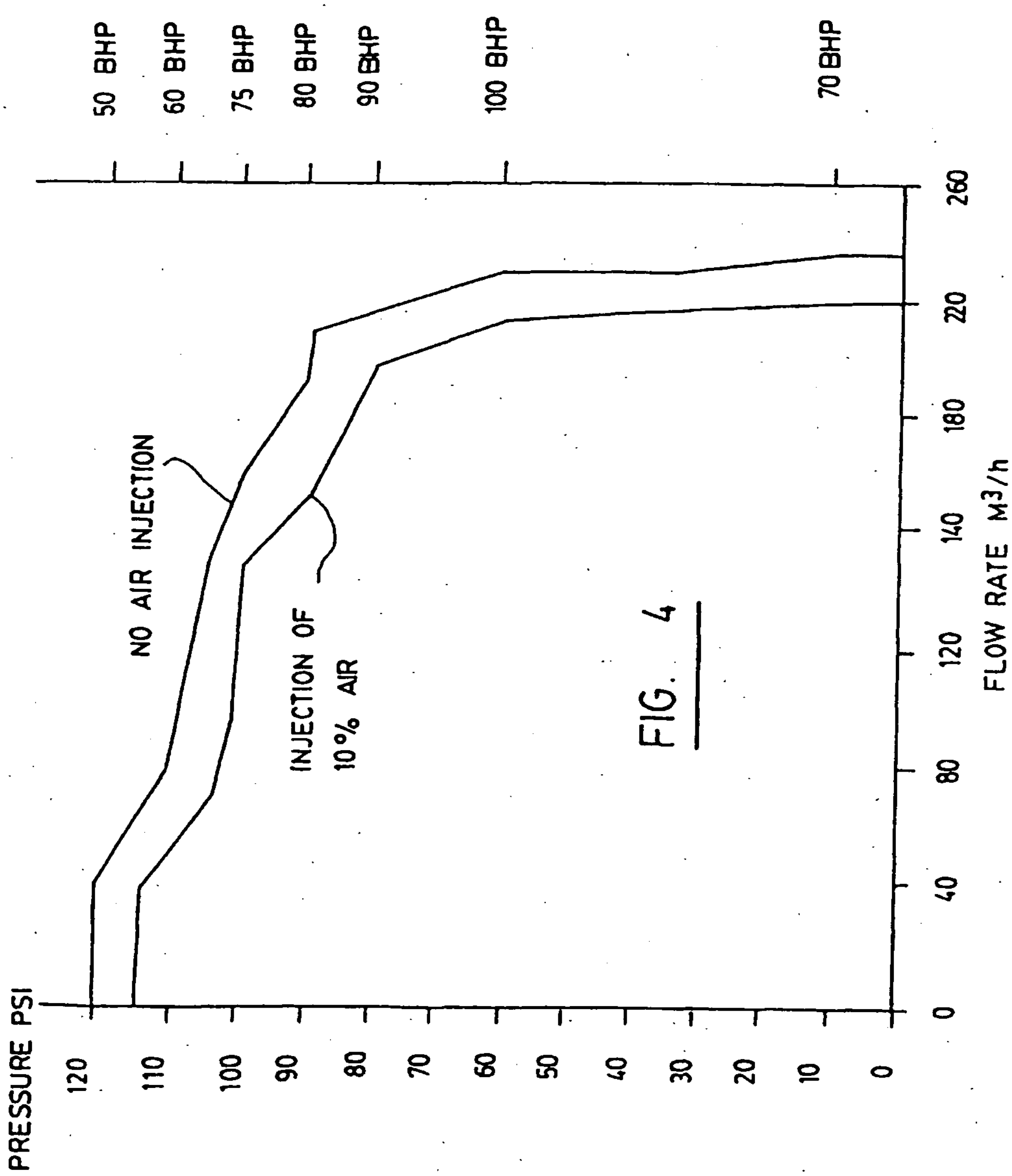
PRESSURE PSI
120
110
100
90
80
70
60
50
40
30
20
10
0
FLOW RATE M3/h
0
40
80
120
140
180
220
260
50 BHP
60 BHP
75 BHP
80 BHP
90 BHP
100 BHP
70 BHP
NO AIR INJECTION
INJECTION OF
10% AIR

FIG. 4